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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This note describes a low cost (\$275 per end) plug replacement for a Bell 303 50KB serial modem using local twisted pair wire for transmission. The unit contains a 50KHz crystal clock and appropriate drivers, receivers, and level shifters to convert the unbalanced local terminal interface to balanced DC signalling for transmission over local twisted pair wire. The note contains a description of the operation of the unit as well as an overview of the subassemblies which comprise the unit and detailed diagrams for each.		

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1B

Plug Compatible Replacement
for a Bell 303 Modem
Using Local Twisted Pair Wire

Put in file

Technical Note No. 91

August 1976

A

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ABSTRACT

This note describes a low cost (\$275 per end) plug replacement for a Bell 303 50KB serial modem using local twisted pair wire for transmission. The unit contains a 50 KHz crystal clock and appropriate drivers, receivers, and level shifters to convert the unbalanced local terminal interface to balanced DC signalling for transmission over local twisted pair wire. The note contains a description of the operation of the unit as well as an overview of the subassemblies which comprise the unit and detailed diagrams for each.

KEY WORDS

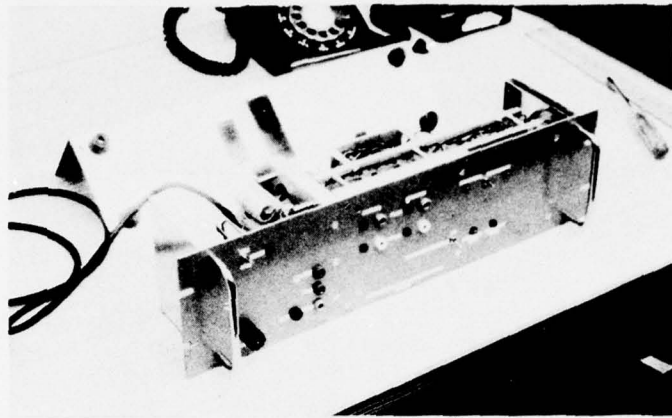
MODEM, LINE DRIVERS, LINE RECEIVERS, PLUG COMPATIBLE BELL 303
MODEM REPLACEMENT, DC BASEBAND SIGNALLING, HIGH SPEED LOCAL
COMMUNICATIION EQUIPMENT

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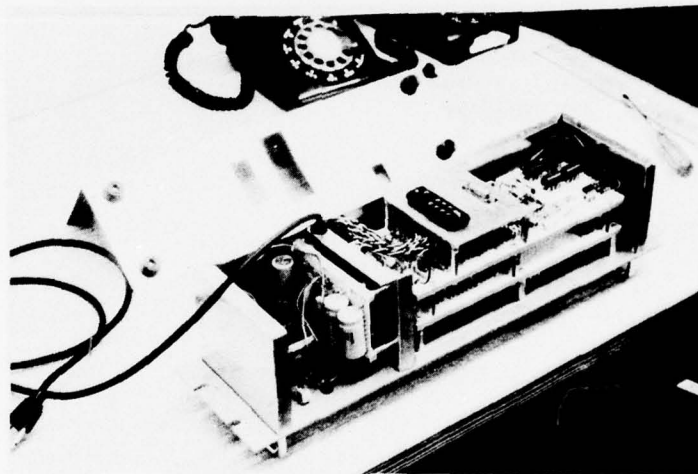
This research was supported by the Defense Advanced Research Projects Agency under ARPA Order No. 2494, Contract No. MDA903-76C-0093.

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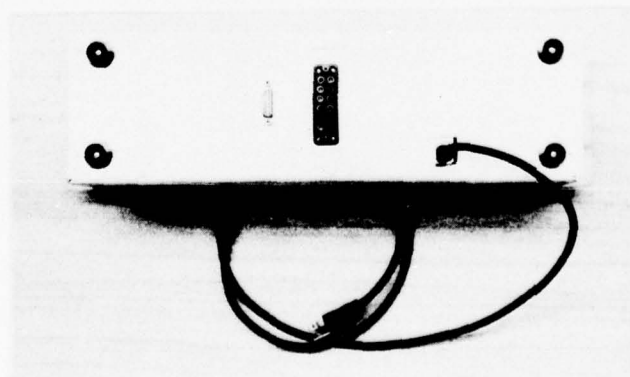
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Unit With Cover Removed



Rear View



Rear View (cover on)

Introduction

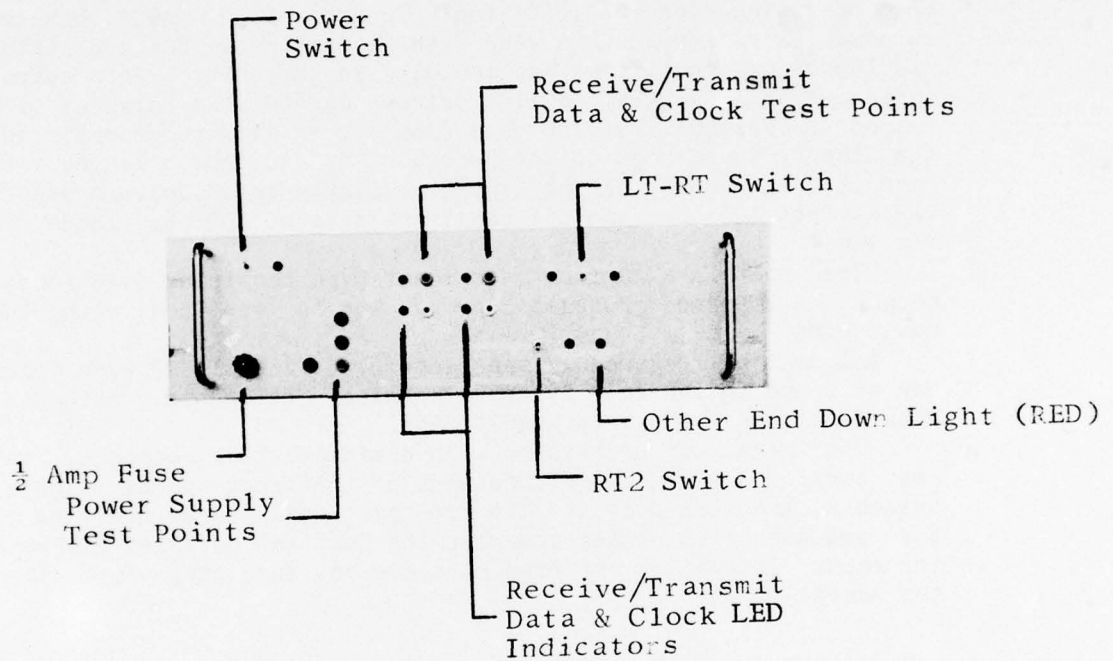
The unit is a low cost (\$275 per end) plug replacement for a Bell 303 50 kilobit serial modem using local twisted pair for transmission. The replacement contains a 50 KHz crystal clock and appropriate drivers and level shifters to convert the 23 mA unbalanced interface from the terminal equipment to a balanced line for transmission over local twisted pair wire. The unit has been operating over a 4,000 foot length of 22 AWG shielded twisted pair for over a year with no failures. Far end status and loopback capabilities are included in the unit. The output impedance of the balanced line drivers is 400 ohms balanced with respect to ground (i.e. 200 ohms from either side to ground) and the input impedance to the receivers is 112 ohms balanced with respect to ground. The unbalanced or single-ended drivers supply +23 mA into 100 ohms and the receivers present 100 ohm loads to the line.

The unit is a 19 inch rack mount type requiring 5.25 inches height. A standard grounded 3 prong plug is supplied with the power cord.

Information regarding the details of a Bell 303 type modem can be found in the Bell System Technical Reference, "Wideband Data Stations, 303 Type", August 1966.

The remainder of this note is divided into 2 sections. The next section describes the functions of the front panel lights, switches, and test points. The last part contains an overview of the subassemblies which comprise the unit and detailed diagrams for each. It enables the reader to see how each part fits into the overall unit.

Front Panel



Power- This switch connects and disconnects the unit from the 120 volt power source. The associated green LED indicates whether power is actually present.

Transmit & Receive Lights and Test Points- The lights are connected to the inputs and outputs of the balanced line transmitters and receivers respectively, as are the test points. The test point levels are TTL. The light is lit if the TTL level is a logic "1" or high. To see the balanced lines directly (instead of receiver output or transmitter input), open the back cover and connect to the appropriate terminating resistor on the balanced driver and receiver board.

LT-RT Switch (center position is NORMAL)

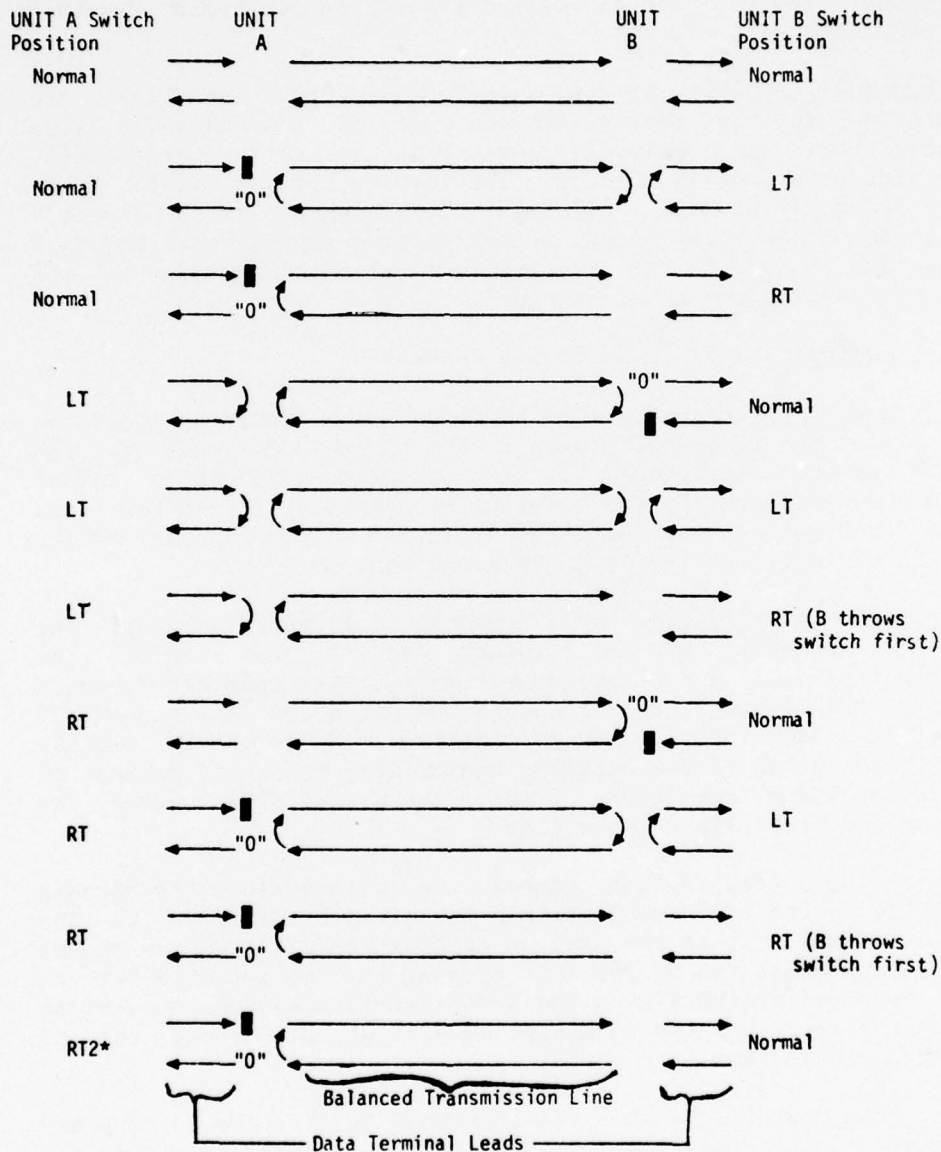
LT Position & Indicator- The LT (local test) function loops the signals on the SD and SCT leads to the RD and SCR leads to the data terminal equipment. It also transmits a "1" on the status lead which disconnects the terminal equipment at the other end. This function can be initiated by either the front panel switch or the LT lead from the local terminal equipment.

RT Position & Indicator- The RT (remote test) function loops the signals received at the distant end of the link to the originating end. A "1" is transmitted on the status lead which causes the distant end to return the clock and data signals it receives. This function can be initiated only by the RT switch. It is inhibited if the received status lead has a "1" present on it or the RT2 switch is on. Both of these conditions cause the "Other End Test" light to be lit.

RT2 Switch- This switch causes the unit to loop the signals received on the balanced line from the distant end back to the distant end. It is the same as setting the LT-RT switch on the distant modem to the RT position causing the receipt of a "1" on the received status line. The local terminal equipment receives a clock signal, but the data line is held at "0" unless the LT function is invoked.

Other End Down Light- This red LED comes on if there is no power received on the receive status line from the other end. This can be caused by the other end having no power or being disconnected. The light being off is not a guarantee that the clock and data lines are secure, but it does indicate the common occurrences of power shutoff and connector removal.

Signal Flow for Various Switch Positions

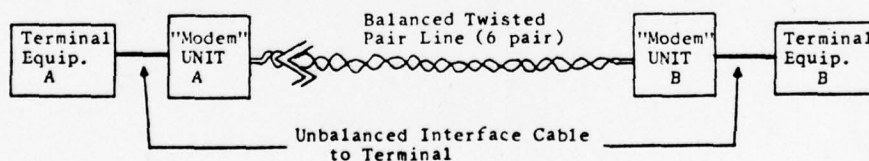


NOTES: * -RT2 allows the user at unit A to simulate the activation of the RT switch on unit B without going to location B.
 "0"-A zero is transmitted on the data lead. The clock lead receives the local clock.
 ■ -The signal is terminated at this point.
 -No marking between the arrows indicates the signal passes straight through in both directions.

2.1 Signal Flow Between Two Interconnected Units

Two modem replacement units are typically interconnected as shown in the interconnection diagram on the next page. The signal flow between the two units for the various front panel switch settings is shown on the following page. The switch referred to in the right and left hand columns is the LT-RT Switch. The last entry in the column for unit A is for the RT2 switch in the ON position and the LT-RT Switch in the NORMAL position. Note also the fact that the states of the switches on the two modem units do not completely determine the state of the system. The switch that was thrown first has priority. The remote test (RT) initiated by unit B prevents unit A from also performing a remote test until unit B switches back to NORMAL. This would be observed by an operator at unit A as follows:

- a) Unit B is switched to remote test (RT) which is indicated by the Other End Test light on the panel of unit A.
- b) The operator at unit A moves the LT-RT switch to the RT position, but the RT indicator light does not come on because it is inhibited by the Other End Test.
- c) Unit B is switched back to NORMAL thus extinguishing the Other End Test light and enabling the remote test and its RT indicator light.



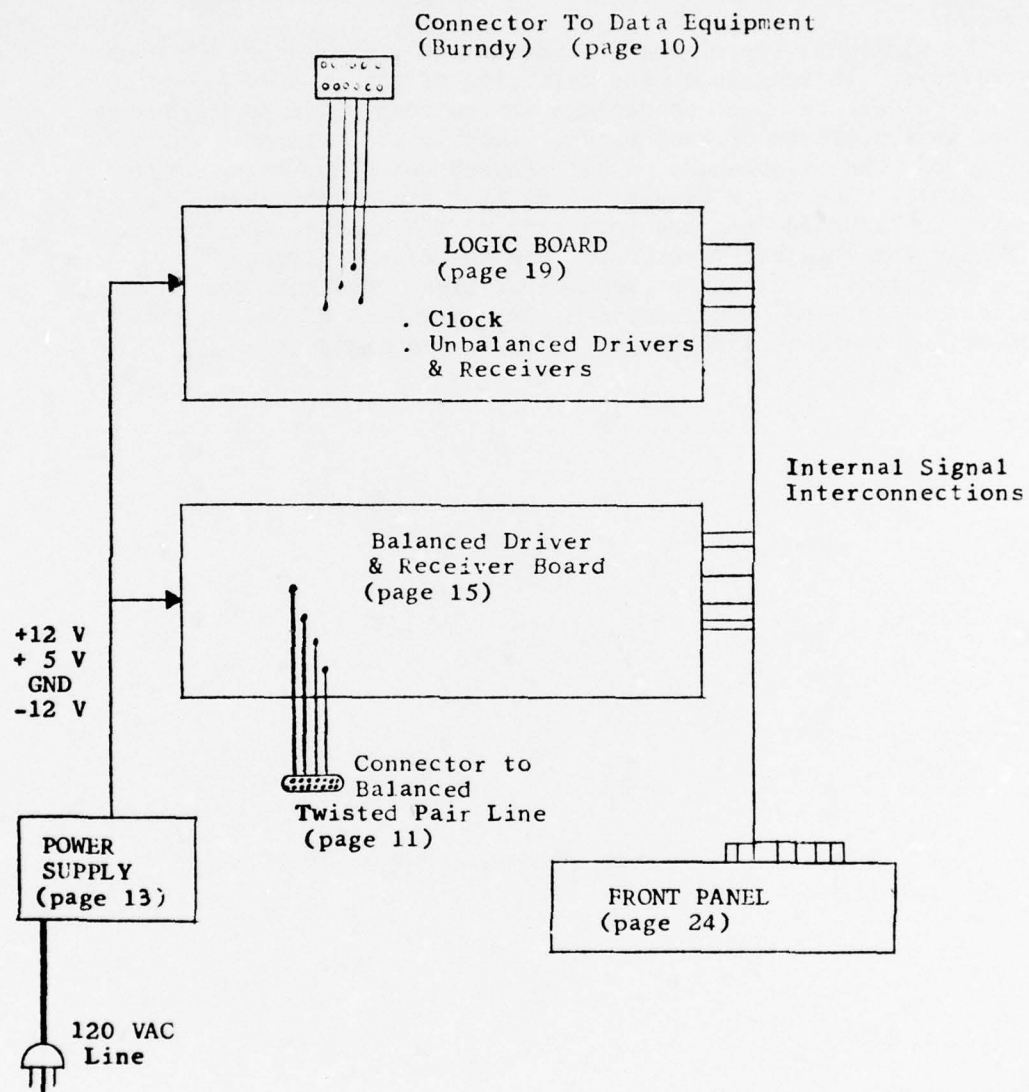
TWO INTERCONNECTED UNITS

This section contains the schematic diagrams and layout details for the modem replacement units. The previous page shows various views of the unit and the following two pages show the wiring interconnections and physical layout of the unit. The details for each subunit start on the pages indicated on the diagram.

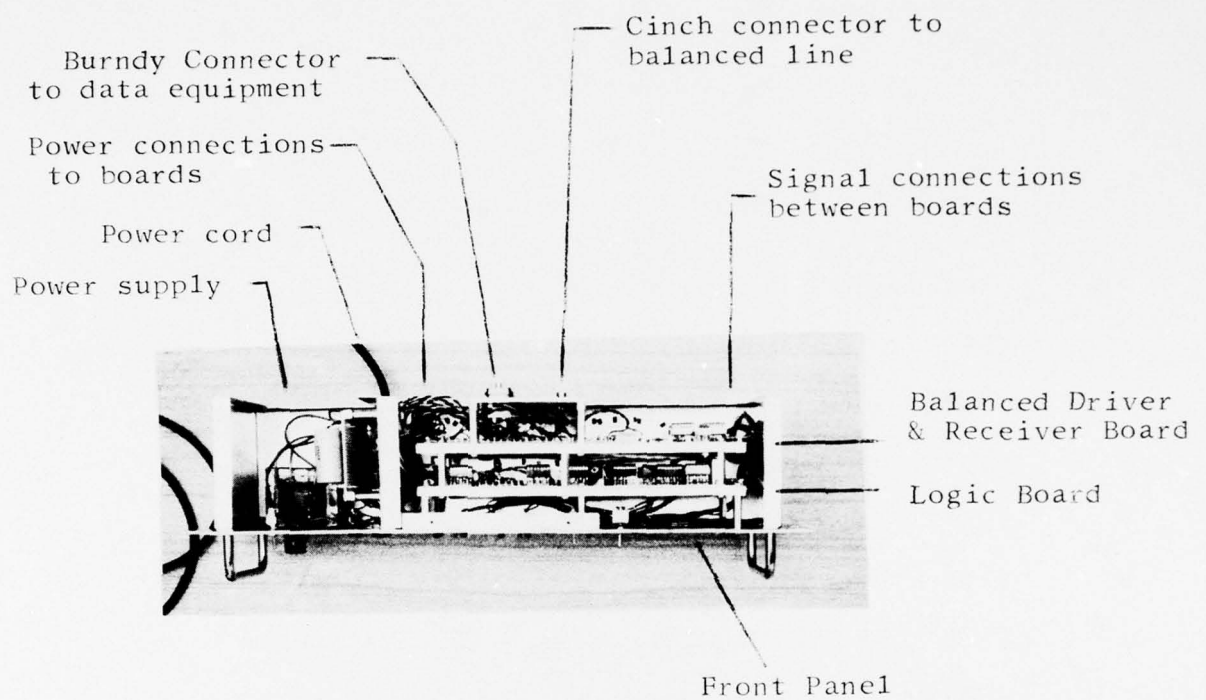
The wiring to the circuit boards are in three groups. First is the power connections on the left side of the board. Second is the wires to the connectors on the rear panel coming from points in the middle of each board. Last is the internal signal wiring on the right-hand side of each board and going to the front panel. The power supply, which also has front panel test points is located on the left side of the chassis and is both logically and physically separate from the signal wiring.

The circuit diagrams show a typical section for the replicated drivers and receivers, but show each of the physical connection points located on the board to aid signal tracing.

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INTERCONNECTION OF BOARDS WITHIN UNIT



PHYSICAL LAYOUT OF "MODEM REPLACEMENT" UNIT

Connector to Local Terminal Equipment

The connector on the rear of the chassis is a Burndy MD12 MXR-ST. It is a multiple coaxial type and costs about \$75.00.

Pin Assignments for connector

Pin	Function
C	(CS) Clear to send
D	(SR) Send Request
E	(SD) Send Data
F	(DSR) Data Set Ready
G	(LT) Local Test
J	(SCT) Serial Clock Transmit (50 KHz square wave)
K	(RD) Receive Data
L	(SCR) Serial Clock Receive (50 KHz square wave)
M	(AGC) AGC Lock (Indicates other end is up)

For further information see the Bell System Technical Reference "Wideband Data Stations, 303 Type," August 1966.

Connector for Balanced Line
Between Modem Units

Connector on rear of chassis is a Cinch DA15-S. One should use a Cinch DA15-P to mate with it. A plastic hood to go with the connector should also be ordered (Cinch DA-51225-1).

The pin connections are as follows for the connector on the rear of the chassis.

Function	Pin Number	
Transmit Clock	1	2
	2	3
Transmit Data	1	4
	2	5
Transmit Status	1	6
	2	7
Receive Clock	1	10
	2	11
Receive Data	1	12
	2	13
Receive Status	1	14
	2	15

WIRING AT STANFORD
(ERL 317A to SUMEX S-101 in Medical Center)

Connector for Bell 303 modem Replacement
(twisted pair size)

6 Pair Beldfoil Shielded cable from ERL 317A to
S-101 in Medical Center (SUMEX)

Connector for cable

Cinch DA-15P connector (1 each end)
DA-19678-1 shell (1 each end)
D20419 screws & clamp (2 each end)

Pin Numbering for wires

		Connector		Wire		ERL 317A
		S-101	ERL 317A	Pin Number	Pair	
Transmit clock	1	2	10	Blk		Receive Clock
	2	3	11	Brn		
Receive clock	1	10	2	Blk		Transmit Clock
	2	11	3	Red		
Transmit Data	1	4	12	Blk		Receive Data
	2	5	13	Yel		
Receive Data	1	12	4	Blk		Transmit Data
	2	13	5	Wht		
Transmit Status	1	6	14	Blk		Receive Status
	2	7	15	Blu		
Receive Status	1	14	6	Blk		Transmit Status
	2	15	7	Grn		
Shields		1, 8	1, 8			

Cable Number from ERL 317A → B061-015

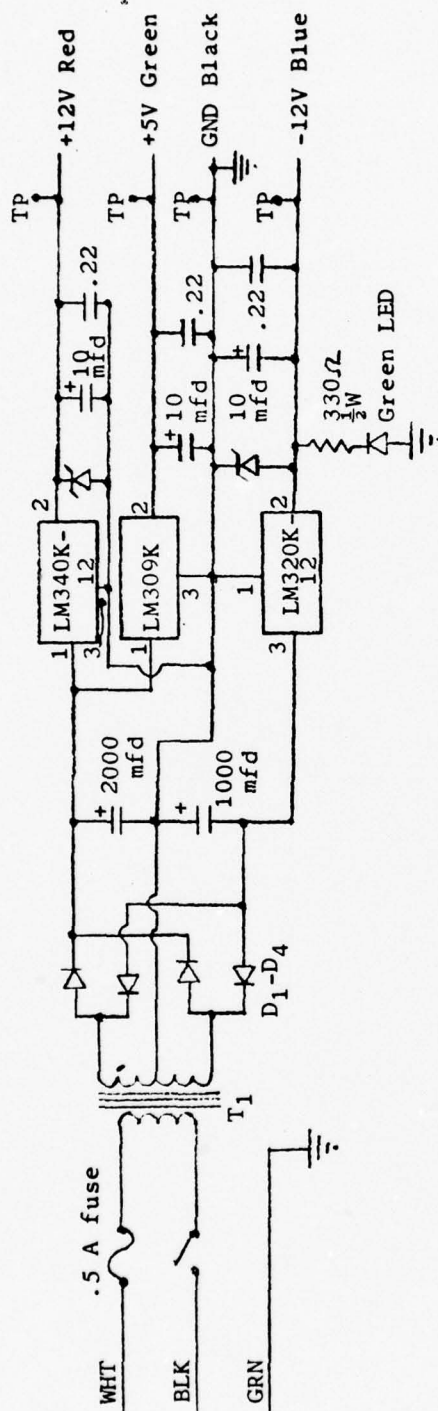
Blk-Blu ↔ Blk-Red
Blk-Yel ↔ Blk-Wht
Blk-Brn ↔ Blk-Grn
Blk-Org ↔ Blk-Blu
Red-Wht ↔ Blk-Yel
Red-Grn ↔ Blk-Brn

Jumper Wiring in ERL 317A
Box Number BTB-12

B061-015 6 pr. cable to connector in ERL 317A

14 μ S Round trip time (i.e. \approx 4,000 feet one way)

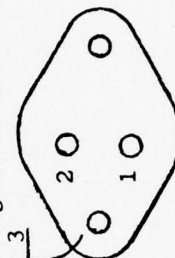
6-30-75



Notes:

1. D₁-D₄ are 1N4002
2. T₁ is 120 volt primary
26.8 volt center tapped
secondary at 1 ampere.
Triad F40X or equiv.
3. Zener diodes are 15V $\frac{1}{2}$ watt.
1N5245B
4. TP - Front panel test point
5. No load voltage on input to regulators is \pm 22 volts.
6. Maximum output current is 1 ampere on any supply.

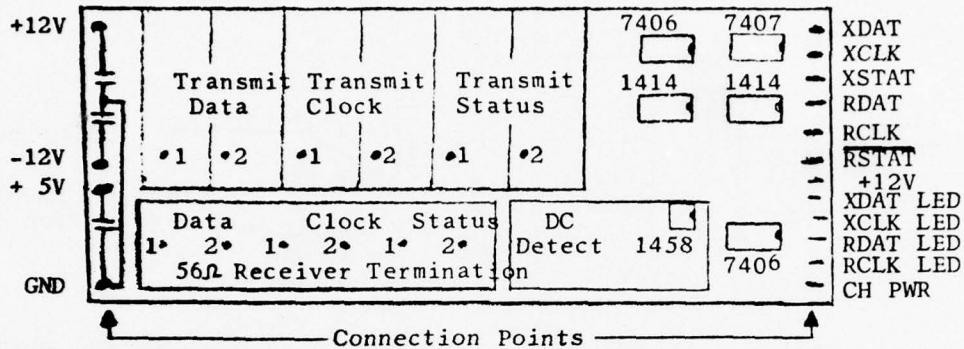
Regulator (Bottom view)



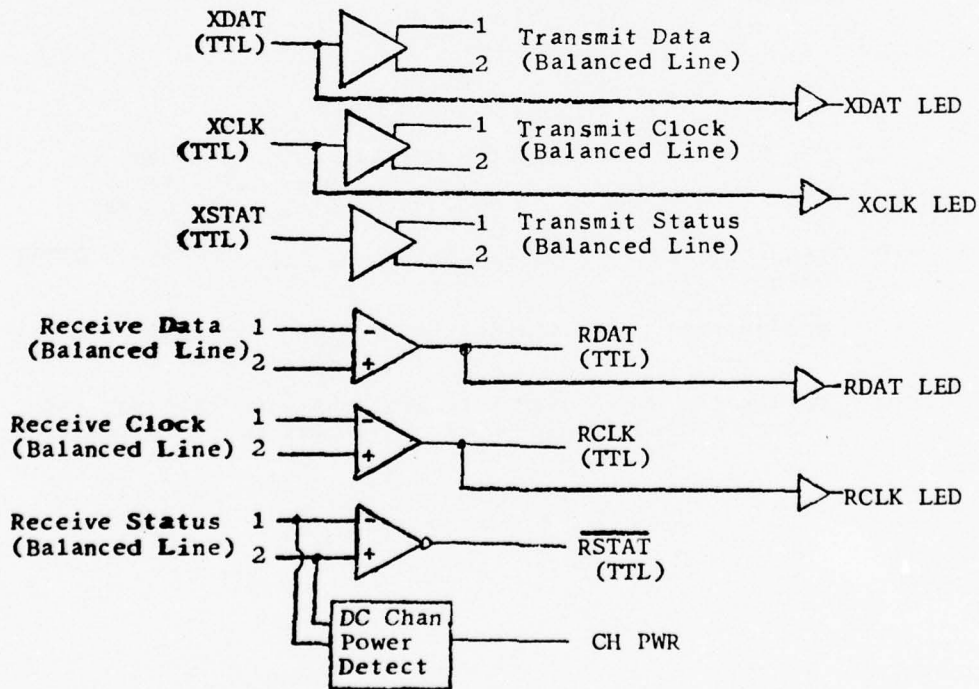
3.1 Power Supply

3.2

Balanced Driver & Receiver Board

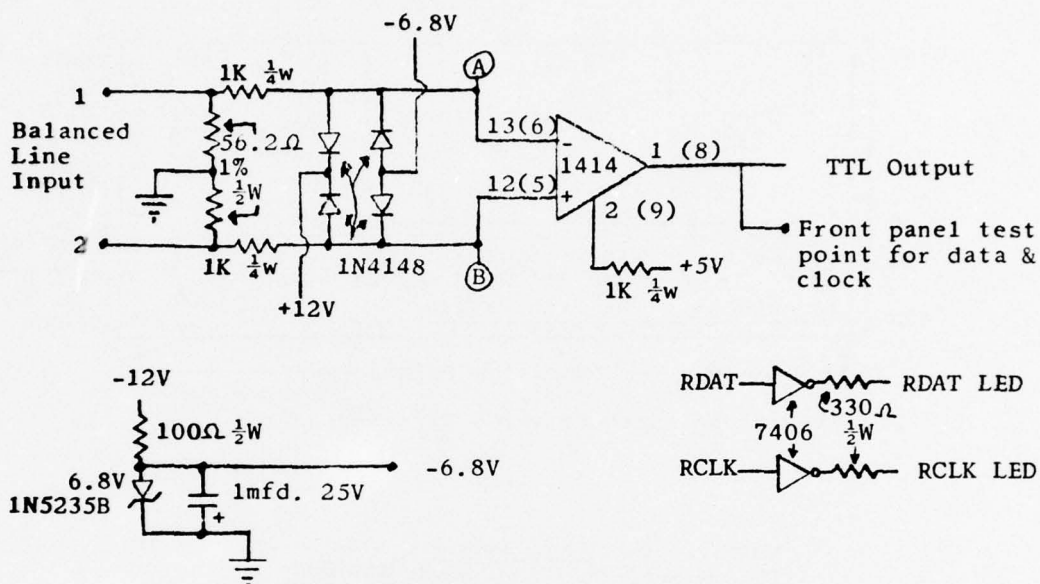


Top View of Balanced Driver & Receiver Board



Functional Diagram of Board

Balanced Receivers

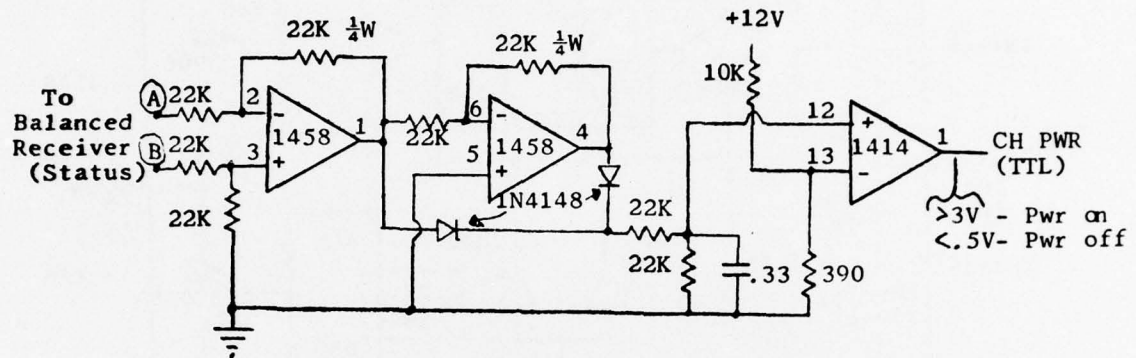


Notes:

- Other pin connections for MC1414:
 - pin 11 - GND
 - pins 3, 10 - +12V
 - pins 7, 14 - -6.8V
- Input wires are reversed on status line to obtain RSTAT output.
- Approximate power consumption:

+12V - 36 mA	}(3 units)
-12V - 52 mA	
- Points A & B are used only in the status receiver and are connected to the DC Channel Power Detect circuit.

DC Channel Power Detection

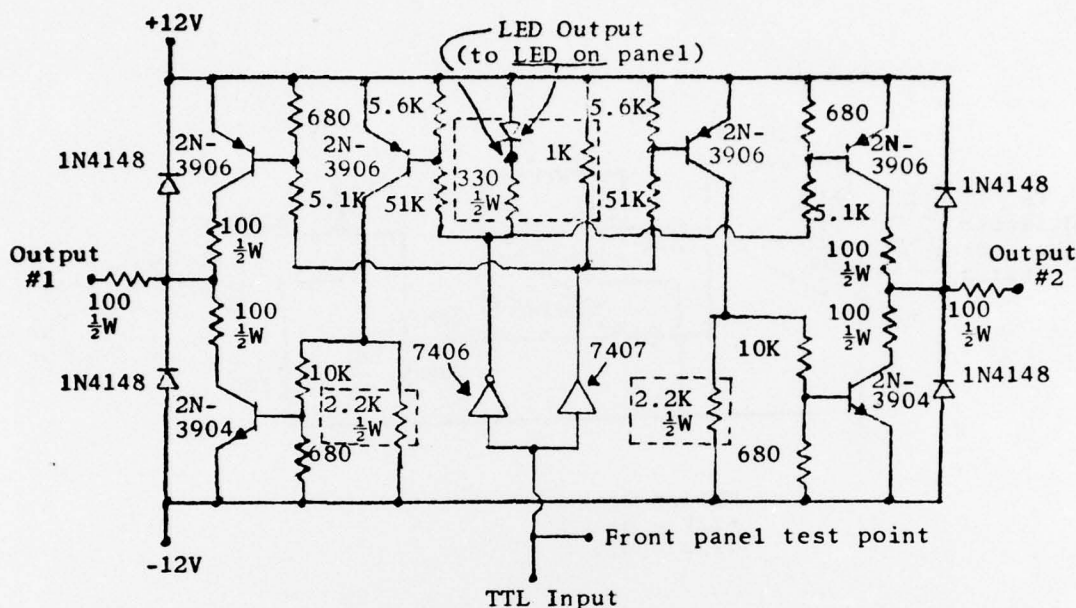


MC1458 Power
 +12V - pin 8
 -12V - pin 4

All resistors are $\frac{1}{4}$ watt.

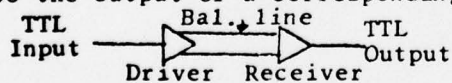
Output is a "1" if the differential input is greater than .5 volt.

Balanced Driver



Notes:

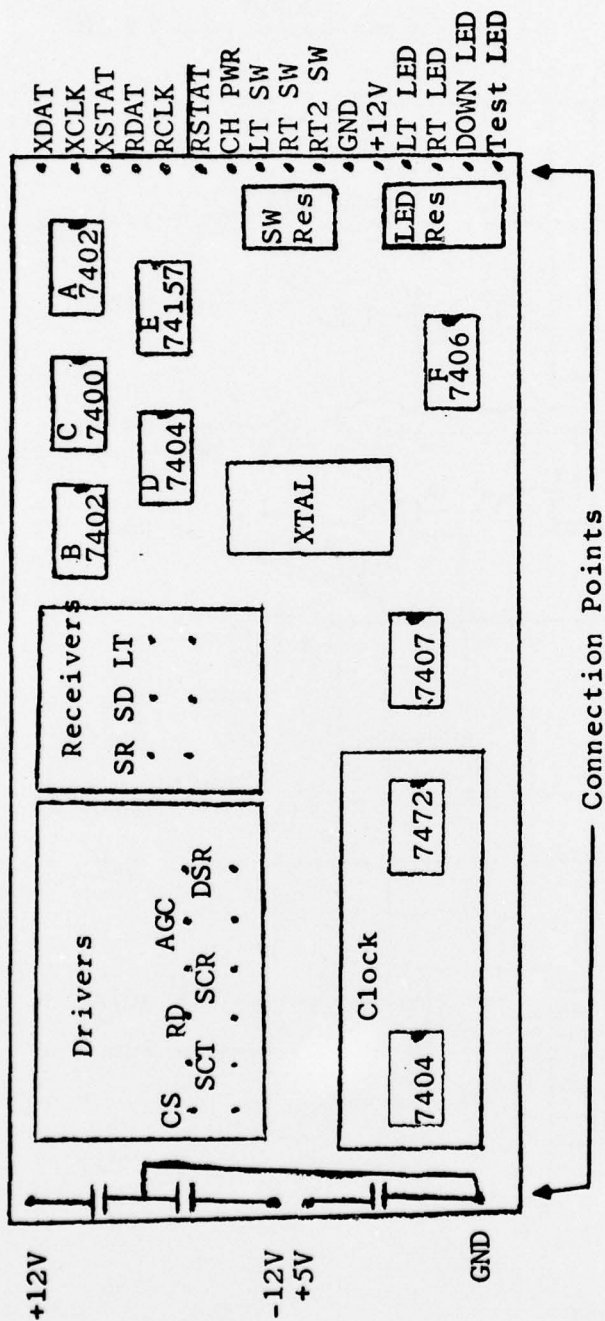
1. Approximate power consumption for 3 drivers:
 +12V - 160 mA
 + 5V - 70 mA
 -12V - 160 mA
2. Parts enclosed in dotted lines are not used in the driver for the status line. They provide faster switching and front panel indication.
3. The approximate time delay from the TTL input of the driver to the output of a corresponding receiver unit is 300 nS.



4. Resistors are $\frac{1}{4}$ watt unless otherwise indicated.
5. The signal on each output wire is either + or - 12 volts in series with a 200 ohm resistor.
6. The polarity of the outputs for a given input are:

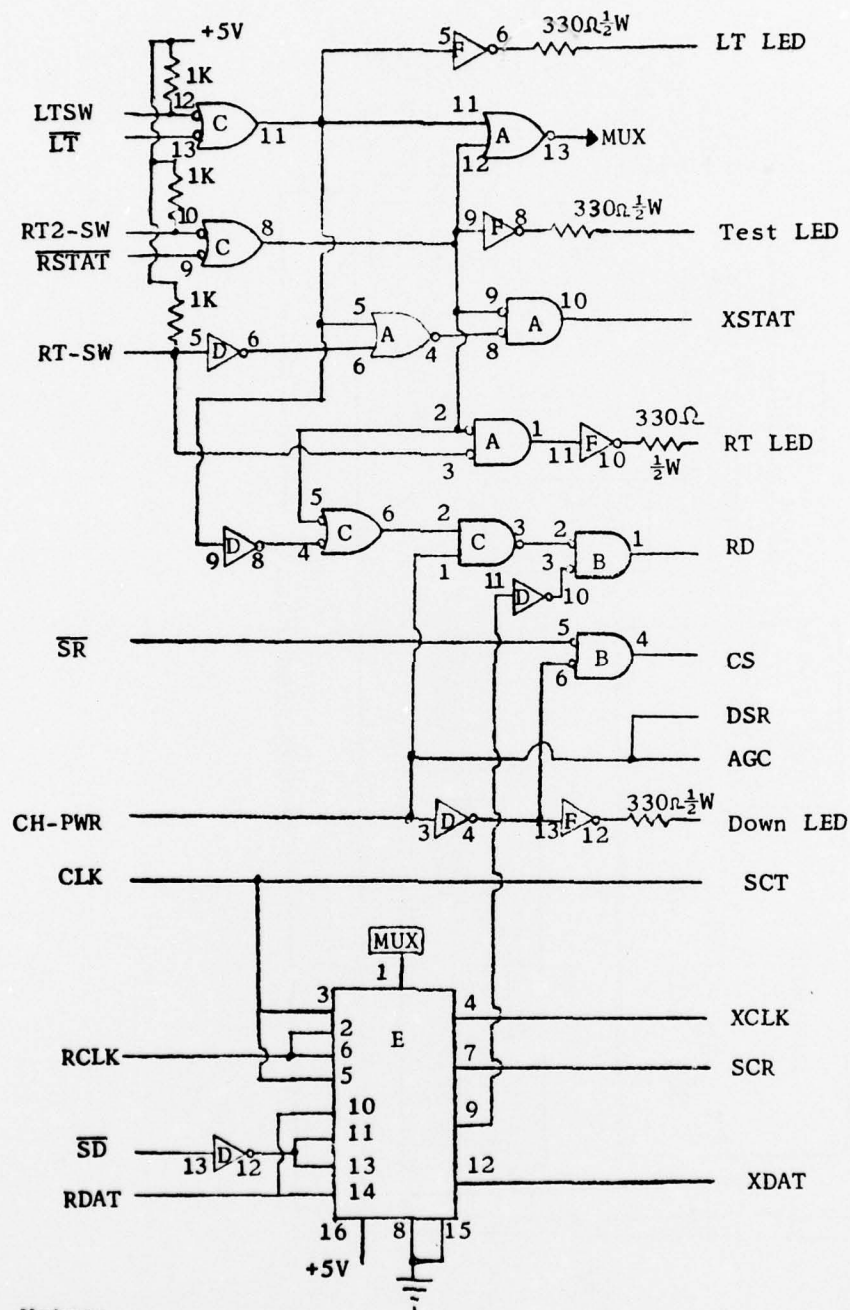
TTL Input		Outputs	
		#1	#2
0	< .5V	+	-
1	> 2 V	-	+

7. The outputs are short circuit proof and diode protected.



3.3 Logic Board Layout (Top View)

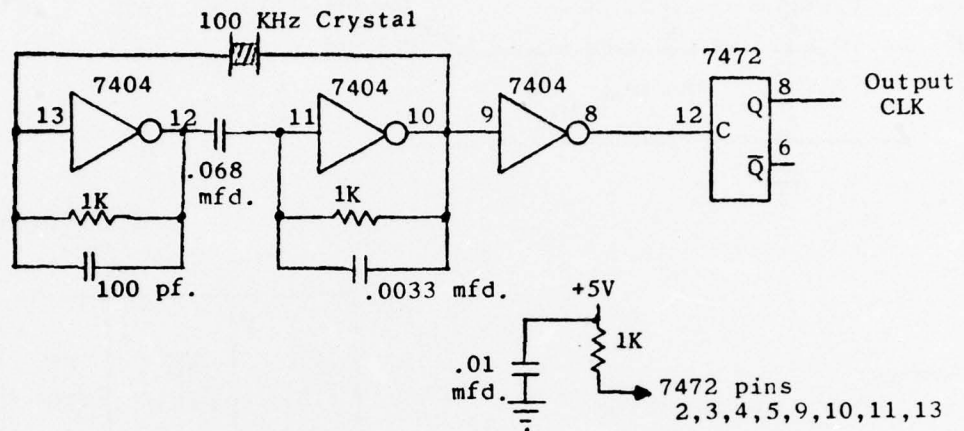
Logic



Notes:

- | | |
|---------|----------|
| A- 7402 | D- 7404 |
| B- 7402 | E- 74157 |
| C- 7400 | F- 7406 |

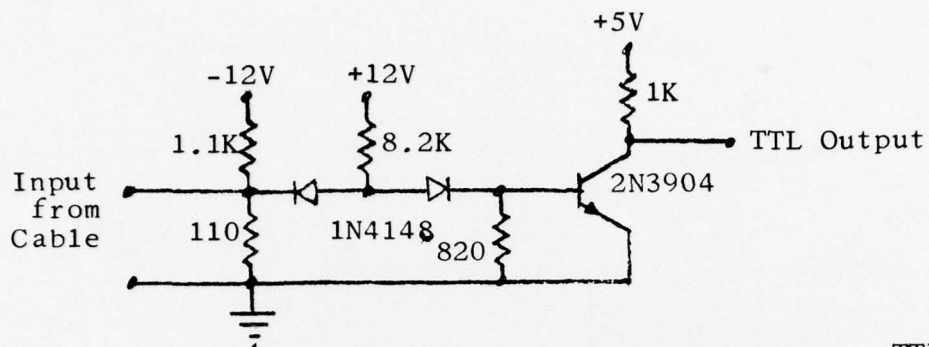
50 KHz Clock



Notes:

1. Power consumption: +5V - 30 mA
2. All resistors $\frac{1}{4}$ watt.

Single Ended Cable Receivers



Notes:

1. Power Consumption:

+12V- 4.5mA

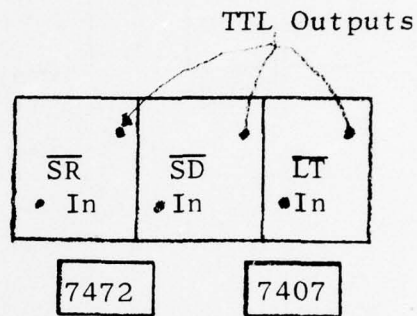
+ 5V- 15 mA

-12V- 30 mA

2. All resistors are $\frac{1}{4}$ watt.

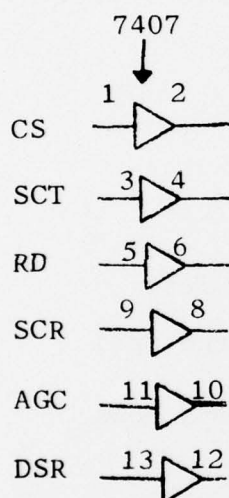
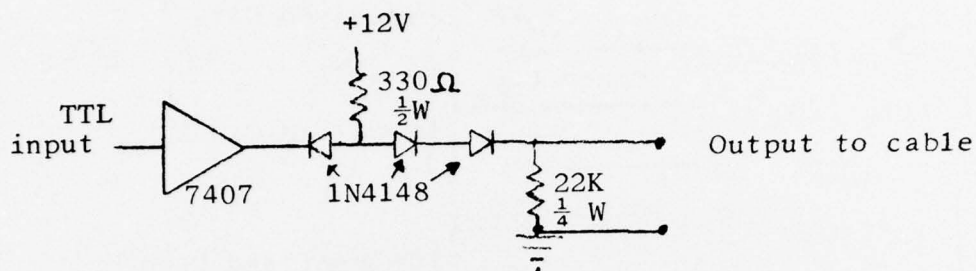
3. +23 mA \rightarrow TTL "0"

0 mA \rightarrow TTL "1"

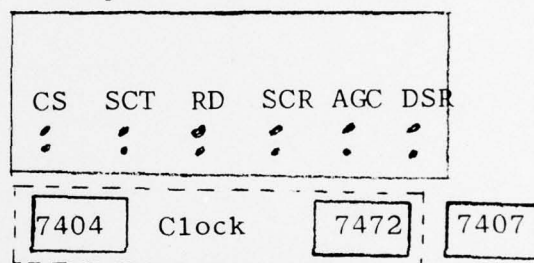


Board Layout (top view)

Single Ended Cable Drivers

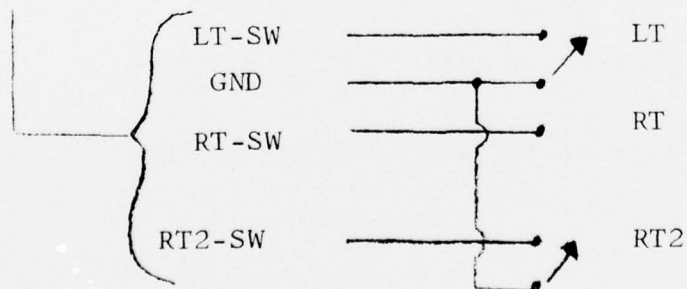
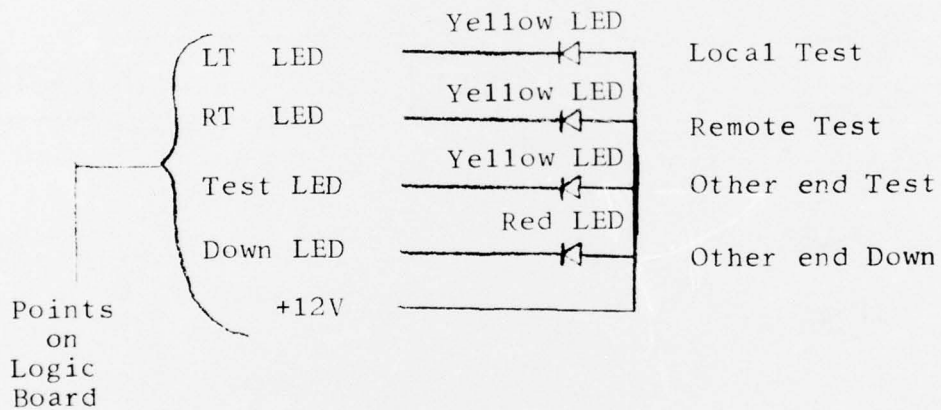
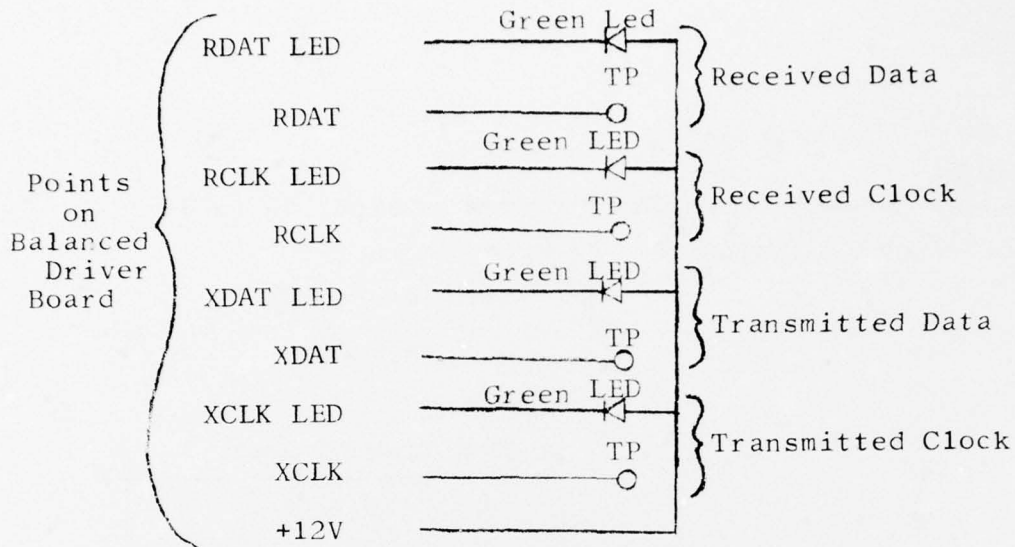


Top View of Board



Notes:

1. Power consumption for 6 units: +12V - 200 mA
+ 5V - 40 mA
2. Output is 25 mA into 100 ohm load for a logic "1" input.



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